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# Kentucky Geological Survey.

## Bulletin No. 5.

# THE UPPER ORDOVICIAN ROCKS OF KENTUCKY AND THEIR BRYOZOA.

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# Kentucky Geological Survey,

CHARLES J. NORWOOD, Director.

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Bulletin No. 5.

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# The Upper Ordovician Rocks of Kentucky and their Bryozoa.

BY

JOHN M. NICKLES.

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UNIVERSITY OF CALIFORNIA

# Letter of Transmittal.

*To His Excellency*, J. C. W. BECKHAM,
*Governor of Kentucky.*

*Sir:*—I have the honor to herewith submit for publication a report on the Upper Ordovician Rocks of Kentucky and their Bryozoa, by Professor John M. Nickles. This is a contribution toward the proper classification of our geological formations, which, as has been stated in another report, is necessary for an intelligent and adequate understanding of their economic values. In order, for example, that we may be able to estimate the depth below the surface at which a known oil or gas-bearing stratum may be found, we must be able to identify the beds seen at the surface and know their relations to other beds in the series of which the oil-bearing stratum forms a member. The identification of particular beds or a group of beds in a series of stratified rocks largely depends upon a knowledge of their characteristic fossils. There is less general knowledge of bryozoa than of other fossil forms, and yet they are often the only trustworthy means for discriminating some of the minor divisions of a formation series. The Survey has been fortunate in having the services of Professor Nickles in dealing with that difficult feature of our classification studies, as they relate to the Upper Ordovician or Cincinnatian rocks. The general study of the Cincinnatian series is in the hands of Professor Aug. F. Foerste. His report, which will include many plates, is in course of preparation.

It seems well to here notice two suggestions made by Professor Nickles. Calling attention to the fact that the Eden beds are the ones that constitute the least fertile of the Ordovician lands, he suggests that a systematic replanting of timber in the Eden areas would be of exceeding value to the State. The suggestion

should receive the serious consideration not only of land-owners, but of the General Aseembly. Such reforesting would not only provide woods for the younger and coming generations, but would serve to limit floods, revive springs, renew soils, and thus enhance the values of the lands. The other suggestion, which raises a question as to the existence of "valuable ore deposits" in Central Kentucky, and limits the conditions permitting vein formation to the Kentucky river region, is not so well considered, unless, as seems probable, Professor Nickles had in mind only the Cincinnatian areas. It is true that no veins have been found in the latter, and that probably none will be found; but, as is shown in other reports, it is a well-determined fact that there are many vein deposits in the interior counties, in the Mohawkian series, away from the Kentucky river, which will doubtless prove of value.

Very respectfully,

CHARLES J. NORWOOD,

*State Geologist.*

LEXINGTON, KY., November 1, 1905.

## Introductory Letter.

WASHINGTON, D. C., October 31, 1905.

PROFESSOR CHARLES J. NORWOOD,

*Director of the Kentucky Geological Survey.*

SIR:—I have the honor to transmit herewith a report on the upper Ordovician rocks of Kentucky and their bryozoa. Owing to the limited amount of time which could be devoted to its preparation, it can be regarded as little more than a sketch.

Very respectfully,

JOHN M. NICKLES.

# The Upper Ordovician Rocks of Kentucky and their Bryozoa.

## Introduction.

A month in the early summer of 1905 was spent by the writer in a rather hasty examination of outcrops in various parts of central and northern Kentucky to determine for geologic mapping purposes the boundaries between formations in certain doubtful cases, and to ascertain to what extent the subdivisions of the Cincinnatian series made in Ohio and Indiana can be recognized in Kentucky. This examination forms the basis of this report. For lack of time a considerable part of the collections of fossils made could not be examined, hence the report lacks the fullness and completeness which the subject deserves. While some problems have become clearer and in a fair way to solution, others have arisen which require additional fieldwork. During part of the time the writer had the guidance of Dr. Aug. F. Foerste and for the remainder that of Prof. Arthur M. Miller, of the State College of Kentucky. To these gentlemen, whose accurate knowledge of Kentucky localities very greatly expedited the purposes in view, is due in large measure what value this report may have. For much other kindness on their part and for pleasant companionship, the writer expresses his thanks; also to Prof. Charles J. Norwood, the Director of the Survey, for many courtesies.

## General.

The blue grass region of Kentucky is widely famed for the fertility of its soil and the consequent prosperous condition of its population. It is a comparatively level country, an old pene-

plain, probably of Tertiary age, according to Campbell,[1] with an average elevation above sea of about 1,000 feet. The surface is sufficiently rolling to be well drained. Its largest streams have not, as a rule, cut very far below the general level, though in some places, as along the Kentucky river, precipitous bluffs have been formed. A level, well drained country, if provided with sufficient rainfall, is bound to be fertile; but if, in addition, the underlying rocks are so constituted that their decomposition provides a soil abounding in the elements needed by plant life, it is doubly so. The Trenton limestones which underlie northern central Kentucky furnish these conditions. Their compactness saves them from rapid erosion, yet they gradually decompose into a fine, mellow soil. Hence the rich blue grass region.

Surrounding this central area is a belt of country varying from 10 to 30 miles in width in which the surface rocks belong to a formation called by Owen siliceous mudrock, by Linney identified as lower Hudson river, later considered the equivalent of the Utica slate of New York, and in this paper termed the Eden shales. In this formation clay shale greatly predominates; the limestones, as a rule, are few and not very thick. Hence it will not hold up. It erodes rapidly and produces a topography in which ridges and hollows are the conspicuous features. Two centuries ago this land was protected by forests, but with the advent of settlers it became cleared for farms. Too late it was found that it required more labor to maintain these farms than they could support, and now much of the land is being abandoned and allowed to take care of itself. Some of it is reforesting itself slowly, other is rapidly finding its way into the Gulf of Mexico. It would seem that the State ought to take these lands in hand and plant them in trees of the valuable kinds and protect these in their growth. It would be an expense to this

[1]U. S. Geol. Surv., Geol. Atlas of U. S., Richmond quadrangle, folio 46, 1898.

generation for which it would receive little return, but oncoming generations would bless their forefathers. The disastrous floods which cause very great loss in the valleys of the large rivers are by many held to be largely due to the extensive deforestation which the land has undergone. This is probably the only way in which these Eden lands can be made of any value at all. No mineral wealth of any kind has yet been discovered in this formation, nor is likely to be. In a great many places it contains materials suitable for the manufacture of Portland cement, but few localities on this formation are favorably situated for shipping facilities or for cheap supplies of fuel. The Eden underlies considerable areas in Kenton, Campbell, Pendleton, Bracken, Robertson, Harrison, Nicholas, Bath, Fleming, Montgomery, Clark, Madison, Garrard, Boyle, Washington, Nelson, Spencer, Anderson, Shelby, Franklin, Scott, Henry, Owen and Grant counties.

Surrounding this belt of usually poor country is another belt in which the higher Ordovician formations produce the soils. These formations contain more limestone than the Eden and hence produce a more fertile land. But in general they do not produce soils equal to those of the blue grass region.

## Geological History.

The region under consideration forms part of what is known as the Cincinnati anticline or uplift, a broad low swell of land with its axis extending from Tennessee northwardly through Kentucky into Ohio where it divides, one branch continuing northwardly through Ohio, the other northwestwardly through Indiana into Illinois. The rocks composing this anticline are all of marine formation. The time of uplift has not been definitely determined. The evidence seems to show that it was a progressive movement, with perhaps occasional halting and even recession. Probably the movement was not always general; some parts may have been slowly rising, while others were

stationary or even subsiding. There may have been times of unrest, with intervals of comparative quiet interspersed.[2]

That the movement of uplift was a slow, gentle one may be inferred from the almost horizontal character of the strata in all the region controlled by the Cincinnati uplift. It was a movement, or series of movements, probably the latter, unmarked by any catastrophes at the time or later. Hence the conditions were wanting which render possible the accumulation of valuable ore deposits. This is true with few exceptions. Some faulting in the Kentucky river region has permitted some vein formation with barite deposits producing some lead and zinc.

The oldest rocks which outcrop in Kentucky and Tennessee are prevailingly limestone and give evidence of rather slow formation in a clear inland sea extending from the Appalachians to the Rockies. This sea has gradually filled up. The Cincinnati island was the first large fill and served as a sort of nucleus, around the sides of which later formations were laid down, derived in part from the waste of its surface. From the earliest times this was probably a shallow part of the sea with deeper areas bordering it.

The Lexington[3] shows more shale than the Stones river or Highbridge. By the close of Lexington time, or soon after, conditions had so changed that a very considerable amount of mud was thrown into the sea. So

---

[2]Not all of these movements may have been actual movements of the solid crust. It is still one of the moot questions in geology what part of the oscillations of land surfaces, which play so large a part in geologic history, has been an actual up and down movement of the solid crust,—if, indeed, one may speak of it as a solid crust—involving a greater or less areal extent, and what part may have been due to a shifting of the waters on the surface of the earth—heaped up in one (or more ?) places and drained from the rest of the sphere's surface—due to causes which may be only surmised.

Possibly also the actual amount of water in the seas may have varied. perhaps at times increased by great volcanic eruptions, and at other times diminished by absorption into rocks in the processes of crystallization. Any change in sea level would produce an apparent elevation or subsidence of land surfaces. Possibly also the amount of ground water has varied.

[3]For the relative position of these formations in the geological scale, see the table of formations on page 13.

the Winchester shows besides its limestones a considerable proportion of clay layers. The next succeeding formation, the Eden, shows a prevalence of shaley and clayey layers. Whether there is an unconformity between the Eden and the underlying Winchester has not been certainly determined. It is probable that slight unconformities, due to some oscillation of the sea bottom, exist between all the groups of formations, Lexington, Winchester, Eden, Maysville and Richmond, but that the decided differences lithologically—the changes are not sudden, yet on the whole pronounced—are due to important changes taking place in the geography elsewhere. Where the land was located from which this muddy sediment was derived, whether to the north or south, or both, is not known, but from the fact thtat the Cincinnatian faunas are more luxuriant in the Cincinnati region than farther south, and that on the whole there are more limestones in all the Cincinnatian formations there than farther south, it seems a fair inference that the mud was brought by currents from the south or southeast. The Cumberland sandstone and Garrard sandstone, the latter gradually replaced by limestone and shale toward the north, also point to a southern origin for the sediment. That the north also contributed material for the growth of the, as yet submerged, island, is indicated by the great thickness of Eden or Utica shales shown by the drill in northern Ohio.

With the close of the Eden there was again a return to conditions which permitted considerable limestone accumulations. The Maysville group has a considerable amount of limestone and a large fauna. Occasionally in some of the Maysville formations there are successions of strata with few or no fossils in Kentucky, while corresponding equivalent strata in Ohio at Cincinnati show abundant fossils. This may be taken as evidence that the movement of muddy sediment from the south continued. This condition of things which began at the close of Lexington, or earlier, and continued through Eden and Maysville,

is more pronounced in the Richmond. Here the Ohio and Indiana regions indicate regions very congenial to animal life, while in Kentucky the faunas are comparatively meagre and considerably different from those of the Ohio-Indiana area, indicating differing zoological provinces, due to the different conditions produced by the progressive shallowing of the bottom.

Probably by the opening of Silurian times some parts of the region had come to be a little above sea level. The Silurian formations on the east and west of the Ordovician area show by their differing lithological character that decided changes had come. Probably later in Silurian time there came an uplift which exposed the land generally to subaerial agencies of decay. After these had been at work for an unknown period, there was again a subsidence which permitted the laying down of Devonian and even later sediments unconformably upon the eroded surface of various Silurian and Ordovician formations. Whether the whole island was submerged and received a new coating, or only part of it, we can not know. All covering of the central part, if such there was, has been removed by erosion.

What vicissitudes beset the island in Carboniferous times, or whether Carboniferous strata overspread the uplift, we can only surmise. No evidence has yet been discovered from which we can infer the conditions then prevailing. Since Carboniferous times the area has been continuously above sea and subject to aerial decay. That an enormous amount of material must have been removed in the time that has elapsed since that ancient day is evident. As pointed out by Campbell, the region seems to have been peneplaned in Cretaceous times, re-elevated, again peneplaned in Eocene time, again elevated, and is now once more undergoing the process of peneplanation.

## Table of Ordovician Formations.

| System | Series | Group | Formation | | |
|---|---|---|---|---|---|
| | | | Ohio and Indiana | Kentucky | New York |
| Ordovician (Lower Silurian) | Cincinnatian Hudson River | Richmond | Saluda (Madison)<br>Whitewater<br>Liberty<br>Waynesville | Saluda<br>Versailles<br>Waynesville | Medina?<br>Oneida? |
| | | Maysville (Lorraine) | Arnheim (Warren)<br>Mount Auburn<br>Corryville<br>Bellevue<br>Fairmount<br>Mount Hope | Arnheim<br>Mount Auburn<br>Corryville<br>Bellevue<br>Fairmount<br>Mount Hope | Lorraine<br>or<br>Frankfort<br>or<br>Salmon River |
| | | Eden (Utica) | Upper<br>Middle<br>Lower | Garrard Sandstone<br>Million | Utica Slate |
| | | Winchester | Point Pleasant | Divisions not yet established | Trenton |
| | Mohawkian (Trenton) | Lexington | Lexington (part)<br>Under Cover | Perryville<br>Paris<br>Wilmore<br>Logana<br>Curdsville | Black River |
| | | Highbridge | Under Cover | Tyrone<br>Oregon<br>Campnelson | Lowville (Birdseye) |
| | Canadian | | | Under Cover | Chazy<br>Beekmantown |

The preceding table presents in outline the succession and grouping of the formations of the Ordovician in the region of the Cincinnati uplift and a comparison with those of the New York system.

## Nomenclature and Notes on the Table.

ORDOVICIAN.—The term Ordovician was introduced by Lapworth in 1879 for what is known as the Lower Silurian, but by some called Upper Cambrian. To escape the ambiguity thereby caused, as to whether in any given case Lower Silurian means the lower part of the whole Silurian, or of the Silurian proper, *i. e.*, Upper Silurian, the term Ordovician is now generally used for the system before known as Lower Silurian.

CINCINNATIAN.—In the early days of geological correlation, the Blue Limestone, as the Cincinnatian series was at first designated, was supposed to be the western equivalent of the Hudson river group of New York. Later Newberry and Orton, in the reports of the Ohio Geological Survey, considering it to have a commingling of both the Trenton and Hudson river faunas (an error), discarded the name Hudson river group for the Blue Limestone in favor of the name Cincinnati group, shortly before proposed by Meek and Worthen. It has now been conclusively shown that the Hudson river group along the Hudson river, its typical area, contains Trenton and other metamorphosed formations. Hence doubt has arisen whether the name can be retained at all. By common consent the name Cincinnati or Cincinnatian has been adopted for the series of formations of upper Ordovician age in the Ohio valley.

RICHMOND.—The term Richmond is applied to the higher formations of the Cincinnatian. It is followed by the Clinton limestone belonging to the Silurian system. In New York, below the Clinton are found the Medina sandstone and the Oneida conglomerate, which are always placed in the Silurian; but no Richmond has been reported. The conclusion seems inevitable that either there is a hiatus at this point in one or the other province, or that the New York Medina and Oneida and the Ohio Valley Richmond are synchronous.

SALUDA AND ARNHEIM.—Within the past few years it has

become customary to avoid the duplication of formation names. As a rule the formation to which the name was first applied retains it. Those which were later called by the same name are given new names. The practice has its disadvantages. Sometimes it compels giving a formation a name other that of its typical locality. As the names Madison and Warren had been used elsewhere prior to their use for Cincinnatian formations, Foerste has substituted for the former Saluda[4] and for the latter Arnheim.[5]

VERSAILLES.—Foerste has pointed out that it is not possible to distinguish the Whitewater and Liberty formations in southern Indiana and in Kentucky. With this the writer's observation agrees. The two are easily distinguishable at Richmond, Indiana, and for some distance away; but it may be that the Whitewater is a somewhat local development and loses its distinctive features within 40 miles away from Richmond. For the middle division of the Richmond Foerste proposes the name Versailles.

MAYSVILLE.—In the Ohio Geological reports the upper beds shown at Cincinnati were designated the Hill Quarry beds. Later these beds, with additions above and below, were identified as the equivalent of the Lorraine of New York. While they are probably synchronous, it seems better to restrict the term Lorraine to the New York formation. Foerste has proposed the name Maysville for these formations. It is a good name as the vicinity of Maysville presents the finest section, perhaps the only complete one.

EDEN.—The name Eden was given by Orton[6] to the beds at Cincinnati, finely exposed at that time along the west slope of Eden Park, extending from the River Quarry beds to the Hill Quarry beds. Later these beds were considered equivalent to the Utica shales of New York, overlying the Trenton limestone.

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[4]American Geologist, *30*, p. 369, 1902.
[5]Science (n. s.) *22*, p. 150, 1905.
[6]Report of Ohio Geological Survey, *1*, p. 370, 1873.

However, as the sediments were deposited in different basins and under very different conditions, and as the faunas have scarcely anything in common, it seems better that they should bear different names; hence Orton's name Eden is revived for the formation developed in the Ohio Valley. Orton[7] takes the view that the Utica is well developed underground in northern Ohio, as shown by well-drillings, but thins out southward towards the Ohio river. He also considers that as the Utica thins the overlying Hudson river shales, as he calls them, increase in thickness. As the two together have a fairly constant thickness, the writer is of the opinion that they together form the Eden. Recently Foerste has given the name Fulton to the clay layers of a few feet thickness at the base of the Eden. As the *Triarthrus becki*, the most characteristic fossil of the New York Utica is found in these few feet, and rarely, if at all, higher, it is held by some that these few feet alone represent the New York Utica.

WINCHESTER AND POINT PLEASANT.—The name Winchester was given by Campbell in the Richmond folio of the Geologic Atlas of the United States to the strata extending from the Flanagan chert to the Garrard sandstone. The Flanagan chert appears to be only a local phase of the upper beds of the Lexington. Fieldwork by members of the Kentucky Geological Survey during the past season has shown that the Garrard sandstone is a local sandy phase of the upper Eden. The upper part of Campbell's Winchester proves to be Eden. The lower part, traced from Winchester north proved to be the same as the Point Pleasant beds, named by Orton from Point Pleasant, Ohio.[8] Orton included them in the Cincinnati group, but excludes them from the Cincinnati beds proper, which he makes begin at low water mark of the Ohio river at Cincinnati. In volume 6 of the Ohio reports Orton definitely calls the Point Pleasant Trenton, but still does not recognize the River Quarry beds at Covington,

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[7]Report of Ohio Geological Sursey, *6*, pp. 7-9, 1888.
[8]Report of Ohio Geological Survey, *1*, p. 370, 1873.

Kentucky, as the upper part of the same beds. Linney referred the Point Pleasant beds to the Trenton. In the writer's paper on "The Geology of Cincinnati"[9] the Point Pleasant beds were placed in the Trenton, as also were the exposures at Covington. The study of the collections made during the past summer has convinced the writer that the fauna is very much more closely related to the Cincinnatian fauna than to that of the Mohawkian. In the rapid alternations of shale and limestone, also, the Winchester has the characteristic Cincinnatian aspect. Altogether, the formation seems to have been deposited under conditions much more like the Cincinnatian than the Mohawkian. Apparently, though more fieldwork is necessary to establish this, there is a marked unconformity between the Lexington and the Winchester, much greater than that between the Winchester and the Eden.

MOHAWKIAN.—The term Trenton has been widely used in the geological literature of this country to designate any formation supposed to be the equivalent of the Trenton of the New York system. This has produced confusion. So Clark and Schuchert[10] have proposed that the term Trenton be restricted to the formation typically displayed on West Canada Creek at Trenton Falls, New York, and that the term Mohawkian include the Trenton, the underlying Black river, and the Lowville or Birdseye.

## Stratigraphy.

The middle and upper Ordovician as developed in the region of the Cincinnati uplift is exceedingly fossiliferous. All classes of invertebrates, capable of preservation as fossils, are represented. The fauna was marine. No undoubted specimens of fish remains have yet been found in this region. Bryozoa and

[9]Journal of the Cincinnati Society of Natural History, *20*, p. 60, 1902.
[10]Science (n. s.) *10*, p. 875, 1899.

brachiopoda, particularly the former, are the prevailing types of animal life. Echinoderms, sponges, mollusks, crustacea, and cœlenterates have many representatives, but are much less abundant, and in some strata are almost wanting. Hence for stratigraphic purposes the bryozoa and the brachiopods are the most important groups. The species of bryozoa are, on the whole, much more limited in vertical range than the brachiopoda, and hence are the more valuable for close correlation work. They have the disadvantage, however, for practical work that they can seldom be identified without a magnifying glass, and require rather careful discrimination. They look much alike at first glance. For careful work microscopic sections are necessary.

The bryozoa seem to have been a rather sensitive type of life, changing readily with changing conditions, yet possessed of great race vitality, for they are abundant even to-day, while the brachiopoda have but few living representatives. However, the suborder of bryozoa most abundant in the Ordovician, the Trepostomata, diminishes greatly at the close of the Ordovician, and at the close of the Paleozoic becomes extinct. On account of the importance of the bryozoa in stratigraphic work in the Cincinnatian series, the paleontologic part of this paper is devoted to them entirely.

## Mohawkian Series.

### Lexington Group.

No attempt is made here to treat this group with any fullness, as the report of Professor Arthur M. Miller describes fully the development of the Lexington and its subdivisions.[11] The formations of the Lexington are mainly limestone, often quite massive. In some parts shale partings are frequent. Fos-

[11]The lead and zinc bearing rocks of Central Kentucky (Ky. Geol. Surv., Bulletin No. 2, 1905).

sils are usually abundant. The following list embraces the species of bryozoa which have been recorded as occurring in the Lexington in Kentucky:

*Callopora multitabulata* (Ulrich).
*Constellaria teres* Ulrich and Bassler.
*Cyphotrypa acervulosa* (Ulrich).
*Cyphotrypa frankfortensis* Ulrich and Bassler.
*Dekayella foliacea* Ulrich and Bassler.
*Dekayella trentonensis* (Ulrich).
*Eridotrypa mutabilis* Ulrich.
*Eridotrypa trentonensis* (Nicholson).
*Homotrypa callosa* Ulrich.
*Homotrypella granulifera* (Ulrich).
*Mesotrypa angularis* Ulrich and Bassler.
*Mesotrypa echinata* Ulrich and Bassler.
*Mesotrypa quebecensis* Ami.
*Monticulipora arborea* Ulrich.
*Prasopora simulatrix* Ulrich.

The commonest and most easily recognizable forms are *Prasopora simulatrix, Callopora multitabulata,* and *Dekayella trentonensis.*

Exposures of these beds were examined at Frankfort and several other points in Franklin county; at Lexington; at Lair, Berry and Claysville in Harrison county; at Falmouth; and along the Ohio river at Carntown, Moscow, and Point Pleasant. The best section seen was at the road leading up from the Crow Distillery, Squire P. O., five miles southeast of Frankfort. At Lair the contact between the Lexington and the Winchester is well shown. The upper beds (uppermost ?) are seen in the banks of the Licking river and its branches at a number of points. Those examined were at Claysville, Berry, and Falmouth. At Carntown, Moscow and Point Pleasant, the Lexington extends to about 40 or 50 feet above low water mark, but only a few feet were exposed at each of these places, enough to prove that the rocks are Lexington, though few fossils were to be had.

## Cincinnatian Series.

### Winchester Group.

As already indicated, the lower part of Campbell's Winchester, as shown at Winchester, the county seat of Clark county, has been traced northward to Point Pleasant and its identity with the Point Pleasant beds established. Lithologically there is not a great deal of change in this distance. The formation contains much more clay than the underlying Lexington and the limestones are not so massive. Under cover, as shown by deep railroad cuts, the limestones and especially the shales are bluish, but towards the surface through oxidation they become yellowish or brownish.

In the Winchester there first becomes noticeable the regular alternations of limestone and shale which are so characteristic of the Cincinnatian series. No satisfactory explanation has yet been offered why there are these rapid alternations of limestone and shale. It may have been that in deposition the argillaceous and calcareous matter were indiscriminately commingled, but subsequently through some segregating process the fine calcareous particles were separated from the clay and concentrated into the limestone layers. The fossils remained where they happened to be, and so are found in either the limestone or in the clay. Some modification of the process due to special conditions may explain the "waved limestones;" the explanation that is usually given for these waved layers that they are ripple marks seems to the writer an almost impossible one.

At several points along the Ohio river between Foster, Ky., and New Richmond, Ohio, notably opposite Moscow, Ohio, and in the vicinity of Point Pleasant, Ohio, these beds have been extensively quarried and the rock shipped by river to Cincinnati and other points. The rock makes a much better building stone than the limestone obtained from the hill quarries at Cin-

cinnati (the Fairmount beds of the Maysville), and is usually specified for the better class of work. In the early history of Cincinnati the upper layers, the only ones outcropping there, were quarried in the Kentucky bank opposite Cincinnati, and these layers, still exposed from West Covington to Ludlow, though no longer quarried, are known locally as the old river quarries.

Fieldwork has indicated that three subdivisions of these beds are present in the central Kentucky region. Further work is, however, necessary to establish these divisions. It is probable that these are represented in the Point Pleasant beds, though in this area the lithological aspect and thickness may be considerably different from farther south.

The upper layers of the Point Pleasant beds are usually rather massive, irregular, crinoidal limestones. They are called crinoidal because they consist in large part of the separated joints of crinoidal stems, all jumbled together. These layers were found at all points where the contact between the Point Pleasant and Eden was seen. Among these places may be cited Winchester, Falmouth, Moscow, Point Pleasant and Covington. In Bourbon and Clark counties these upper layers seem to be more strongly developed than farther north.

The Winchester fauna is a fairly large one. Fossils are usually abundant, particularly in certain layers. *Cyclonema varicosum, Eridotrypa briareus* and *Constellaria emaciata* may be regarded as the characteristic fossils, as they range through most of the group and may usually be found with a little search. A medium-sized species of *Rafinesquina* is also rather abundant at most places. Poorly preserved casts of some gastropods, *Lophospira, Protowarthia,* and *Raphistona,* and of some lamellibranchs are also fairly common. Superficially the fauna has considerable resemblance of that of the Fairmount in the Maysville group, but the species are entirely different. *Plectambonites sericeus* occurs sporadically, particularly at the north.

Fragments of *Trinucleus concentricus* are rather common and those of *Asaphus gigas* very common.

The bryozoa include the following:

*Aspidopora calycula* (James).
*Constellaria fischeri* Ulrich.
*Constellaria emaciata* Ulrich and Bassler.
*Crepipora spatiosa* Ulrich.

*Eridotrypa briareus* (Nicholson).
*Eridotrypa mutabilis* Ulrich.
*Escharopora ponderosa* Ulrich.

*Heterotypa parvulipora* Ulrich and Bassler.
*Homotrypella norwoodi n. sp.*
*Peronopora milleri n. sp.*

Of these *Eridotrypa briareus* is very common and a characteristic species.

The principal localities where exposures were examined were Lexington (cut on L. & E. R. R.), Winchester (several railroad cuts, showing from 30 to 40 feet vertically); a small, abandoned quarry on Big Stoner Creek, near the Winchester--Mt. Sterling pike; several railroad cuts on the L. & N., between Pleasant Valley and Park's Ferry station; Lair station (railroad cuts); Cynthiana; Boyd's station; Falmouth (several small quarries and other exposures); Moscow (quarries for several miles along the Kentucky bank of the Ohio river); Point Pleasant, Ohio (several quarries); and Covington. The abandoned quarry on Indian Creek, a short distance east of Point Pleasant, proved the best collecting ground for fossils. One-quarter mile west of Point Pleasant is a ravine which gives a complete measurable section of the Point Pleasant beds, though the contact between the Lexington and the Winchester is concealed. The section here gives the thickness of the Winchester as about 60 feet, its base being taken at 60 feet above low water. At Covington and Ludlow the top of the Winchester is about 50 feet above low water mark.

### Eden Group.

In volume 1 of the reports of the Geological Survey of Ohio, Orton applied the term Eden to the beds, very largely shale, extending from the River Quarry beds to the Hill Quarry beds in the vicinity of Cincinnati. When the name was given the beds were well exposed along the western side of Eden Park. Even beds near the base of the Eden were shown in Duck Creek at the foot of the slope. The growth of the city and the improvement of the park have obliterated these exposures. At the present time exposures are frequently presented along the lower slopes of the hills immediately surrounding the lower part of the city and on the sides of the hills back of Newport and Covington.

In Ohio and Indiana the Eden shales outcrop only on the slopes of the hills adjoining the Ohio river and in the valleys of the streams flowing into it. In Kentucky the Eden forms the surface rock of a considerable area, forming a belt from 5 to 15 or more miles wide surrounding the Blue Grass region.

In the paper on "The Geology of Cincinnati," the writer divided the Eden into three divisions called upper, middle and lower. Faunal designations were given to these divisions but not geographic names. No good dividing lines were detected that could be recognized readily. The Eden is much more homogeneous than the Maysville. The upper division in the vicinity of Cincinnati has a somewhat different aspect from the lower and middle divisions.

In central Kentucky the upper Eden which has there been called the Garrard sandstone, differs considerably from the underlying shales. For the latter Mr. Foerste, in a letter to the writer, has suggested the name Million, from a station on the Louisville and Atlantic Railroad. This name will be here used to designate so much of the Eden as lies between the Winchester and the Garrard sandstone. The latter formation in central

Kentucky is a very fine grained sandstone, but as it is traced north the sand is found to gradually give place to clay and calcareous matter.

At Newport the Eden is about 260 feet thick, No sections were met farther south which permitted measurement, so it can not be stated whether the vertical thickness remains the same or decreases.

The three divisions of the Eden, especially the lower division, in the vicinity of Cincinnati, Newport and Covington have yielded an extensive and varied fauna, as the result of many years' collecting by many collectors. Comparatively few forms are really common and they comprise the bulk of the fauna. *Dalmanella multisecta* and *Plectambonites sericeus* are the common brachiopods. In the field the Eden can usually be distinguished from the underlying Winchester by its shaly character and the invariable presence in its lower layers of *Plectambonites sericeus* and *Callopora sigillarioides*. *Plectambonites sericeus* occurs in the Winchester but is rare; as soon as the Eden appears it becomes abundant.

Among the forms which range through the Eden are *Batostoma implicatum* (Nicholson), *Callopora communis* (James), *Callopora sigillarioides* (Nicholson), *Ceramoporella ohioensis* (Nicholson), *Peronopora vera* Ulrich, *Stomatopora arachnoidea* (Hall), *Dalmanella multisecta* (James), and *Plectambonites sericeus* (Sowerby). This applies to the northern area.

Exposures of Eden are very abundant, on account of the rapid erosion to which it is subject. Only incidental attention was given to the Eden in the fieldwork of the past summer. Exposures were examined in the vicinity of Lexington, near the reservoir, where a fault has caused the preservation of some Eden; along the L. & N. R. R. in Nicholas county between Park's Ferry Station and Carlisle; at the top of the Crow Distillery section, five miles southeast of Frankfort, where the base of the Eden is seen resting on the Winchester; at Falmouth where sev-

eral exposures were found in the upper part of the hill sides; along the Ohio river, from Foster down, overlying the Winchester; railroad cuts in the vicinity of Million in Madison county; and in Limestone Creek near Maysville.

The following list gives the bryozoa which have been found in the vicinity of Newport and Covington. Most of the common ones have also been found farther south. It is probable that continued careful collecting will discover there some of the rarer forms, and perhaps some hitherto unknown:

## LIST OF EDEN BRYOZOA.

| | Lower | Middle | Upper |
|---|---|---|---|
| *Amplexopora persimilis n. sp.* | c | | |
| *petasiformis* (Nicholson) | c | c | |
| *petasiformis-welchi* (James) | | c | |
| *septosa* (Ulrich) | | | c |
| *Arthropora cleavelandi* (James) | | | c |
| *Arthrostylus curtus* Ulrich | rr | | |
| *tenuis* (James) | cc | c | c |
| *Aspidopora areolata* Ulrich | r | | |
| *eccentrica* (James) | | c | |
| *newberryi* (Nicholson) | r | | |
| *Atactopora hirsuta* Ulrich | r | r | r |
| *Atactoporella newportensis* Ulrich | g | | |
| *typicalis* Ulrich | r | | |
| *Batostoma implicatum* (Nicholson) | c | cc | cc |
| *jamesi* (Nicholson) | | cc | c |
| *Berenicea vesiculosa* Ulrich | | | rr |
| *Bythopora arctipora* (Nicholson) | c | c | c |
| *parvula* (James) | | | c |
| *Callopora communis* (James) | c | cc | c |
| *nodulosa* (Nicholson) | | | c |
| *onealli* (James) | cc | | |
| *sigillarioides* (Nicholson) | cc | cc | cc |
| *Ceramoporella distincta* Ulrich | c | c | c |
| *milfordensis* (James) | | | c |
| *ohioensis* (Nicholson) | c | c | c |
| *Cœloclema alternatum* (James) | | c | cc |
| *concentricum* (James) | cc | c | c |
| *Constellaria prominens* Ulrich | | | nr |
| *Crepipora simulans* (Ulrich) | | | r |
| *solida* Ulrich | rr | | |
| *venusta* (Ulrich) | nr | | |
| *Dekayella obscura* Ulrich | | | c |
| *ulrichi* (Nicholson) | c | cc | cc |
| *ulrichi-robusta* Foord | | | r |
| *Dekayia maculata* James | | | c |
| *Escharopora acuminata* (James) | nr | | |
| *falciformis* (Nicholson) | | | r |
| *Hemiphragma whitfieldi* (James) | c | c | |
| *Heterotrypa foerstei n. sp.* | nr | | |
| *Homotrypa curvata præcipta* Bassler | | r | |
| *Leptrotrypa cortex* Ulrich | rr | | |
| *Monotrypa turbinata* (James) | nr | | |
| *Monotrypella æqualis* Ulrich | rr | | |
| *Peronopora vera* Ulrich | c | c | cc |
| *Phylloporina variolata* Ulrich | | | r |
| *Proboscina confusa* (Nicholson) | r | r | r |
| *Rhinidictya parallela* (James) | nr | | |
| *Stictoporella flexuosa* (James) | c | | |
| *Stigmatella clavis* (Ulrich) | c | nr | nr |
| *nana* Ulrich and Bassler | nr | | |
| *Stomatopora arachnoidea* (Hall) | c | c | c |

Explanation of symbols: c = common, cc = very common, r = rare, rr = very rare, nr = not rare, g = gregarious, i. e., occurs in pockets containing many specimens, but the pockets usually rare.

### Maysville Group.

The name Maysville is here used for that division of the Cincinnatian to which the New York name Lorraine has been applied for several years past. The name is taken from Maysville where a magnificent series of railroad cuts on the L. & N. between Maysville and the next station, Summit, presents a complete section showing practically all the layers of all the subdivisions. The Maysville in the area south of the Ohio river on both the east and west sides of the Blue Grass basin is much less fossiliferous as a whole than in the area north of the Ohio river. Lithologically also there are considerable differences. There is little difficulty however in recognizing the subdivisions which have been made in Ohio. These subdivisions are here treated in ascending order.

In Ohio the brachiopod *Rafinesquina alternata* and its varieties is perhaps the most abundant fossil of the Maysville, being found in all subdivisions and also ranging through the Richmond. The large *Platystrophia lynx* occurs rather sparingly in the Fairmount, Bellevue and Corryville, is exceedingly abundant in the Mount Auburn, and occurs at two or three horizons in the Arnheim beds. In Kentucky, the *Rafinesquina,* while rather abundant at some horizons, is on the whole an uncommon fossil, while the large *Platystrophia lynx* occurs abundantly in all the Maysville formations, and is frequently the most abundant fossil. Here as well as in the northern area, it occurs in the greatest profusion in the Mount Auburn beds. The *Zygospira modesta* is found everywhere in the Maysville.

As the bryozoa of the Maysville group in Kentucky have not yet been thoroughly investigated, it may be of value to give a list of the described species of bryozoa which have been recorded from the three States of Ohio, Indiana and Kentucky. Nearly as many undescribed species are known as have been described:

## LIST OF MAYSVILLE BRYOZOA.

| | Mount Hope | Fair-mount | Belle-vue | Corry-ville | Mount Auburn | Arn-heim |
|---|---|---|---|---|---|---|
| *Amplexopora ampla* Ulrich and Bassler | | r | | | | |
| *cingulata* Ulrich | | g | | | | |
| *discoidea* (Nicholson) | | nr | | | | |
| *filiosa* (D'Orbigny) | | | c | nr | | |
| *robusta* Ulrich | | | nr | | | |
| *septosa* (Ulrich) | c | | | | | |
| *Arthropora shafferi* (Meek) | | | | c | | |
| *Atactopora hirsuta* Ulrich | | r | | | | |
| *maculata* Ulrich | | rr | | | | |
| *Atactoporella multigranosa* (Ulrich) | | r | r | | | |
| *mundula* (Ulrich) | | r | r | | | |
| *ortoni* (Nicholson) | | | c | | | |
| *tenella* (Ulrich) | | r | r | | | |
| *Batostoma maysvillensis n. sp.* | c | | | | | |
| *varians* (James) | | | | | | c |
| *Berenicea primitiva* Ulrich | | | | r | | |
| *Bythopora dendrina* (James) | | nr | | nr | | |
| *gracilis* (Nicholson) | | c | c | cc | c | c |
| *striata* Ulrich | | | | | | c |
| *Callopora andrewsi* (Nicholson) | | c | | c | | |
| *dalei* (Edwards and Haime) | c | c | | | | |
| *nodulosa* (Nicholson) | c | | | | | |
| *ramosa* (D'Orbigny) | | | c | c | | |
| *rugosa* (Edwards and Haime) | | | | c | | |
| *subplana* (Ulrich) | c | | | | | |
| *Ceramoporella distincta* Ulrich | r | c | | c | | |
| *ohioensis* (Nicholson) | c | cc | c | cc | c | c |
| *whitei* (James) | | | c | c | c | c |
| *Chiloporella nicholsoni* (James) | | | | c | | |
| *Coeloclema oweni* (James) | | | | | c | |
| *Constellaria florida* Ulrich | | c | | | | |
| *plana* Ulrich | r | r | | | | |
| *prominens* Ulrich | c | | | | | |
| *Crepipora impressa* Ulrich | | rr | | | | |
| *simulans* Ulrich | | r | | | | |
| *Cyphotrypa semipilaris* (Ulrich) | | r | | | | |
| *Dekayia appressa* Ulrich | | | | c | | |
| *aspera* Edwards and Haime | | c | | | | |
| *multispinosa* Ulrich | | r | | | | |
| *pelliculata* Ulrich | | | | rr | | |
| *Dicranopora emacerata* (Nicholson) | r | r | | | | |
| *internodia* (Miller and Dyer) | | c | | | | |
| *Discotrypa elegans* (Ulrich) | | r | | | | |
| *Escharopora falciformis* (Nicholson) | | nr | | | | |
| *hilli* (James) | | g | | | | |
| *maculata* (Ulrich) | | r | | | | |
| *pavonia* (D'Orbigny) | | c | | | | |

## LIST OF MAYSVILLE BRYOZOA—Continued.

| | Mount Hope | Fair-mount | Belle-vue | Corry-ville | Mount Auburn | Arn-heim |
|---|---|---|---|---|---|---|
| *Heterotrypa cystata* (Cumings) | .... | nr | .... | .... | .... | .... |
| *frondosa* (D'Orbigny) | .... | .... | .... | c | .... | .... |
| *inflecta* Ulrich | .... | .... | .... | c | .... | .... |
| *paupera* Ulrich | .... | .... | .... | nr | .... | .... |
| *solitaria* (Ulrich) | .... | rr | .... | .... | .... | .... |
| *subfrondosa* (Cumings) | nr | .... | .... | .... | .... | .... |
| *subpulchella* (Nicholson) | c | .... | .... | .... | .... | .... |
| *Homotrypa bassleri* Nickles | .... | .... | .... | .... | .... | nr |
| *cincinnatiensis* Bassler | .... | nr | .... | .... | .... | .... |
| *curvata* Ulrich | .... | c | .... | .... | .... | .... |
| *dumosa* Bassler | .... | r | .... | .... | .... | .... |
| *flabellaris* Ulrich | .... | c | .... | .... | .... | .... |
| *flabellaris-spinifera* Bassler | .... | c | .... | .... | .... | .... |
| *libana* Bassler | .... | .... | .... | .... | .... | r |
| *obliqua* Ulrich | .... | c | c | c | .... | .... |
| *pulchra* Bassler | .... | .... | .... | .... | c | .... |
| *Leptotrypa calceola* (Miller and Dyer) | .... | .... | .... | g | .... | .... |
| *clavacoidea* (James) | .... | .... | .... | c | .... | .... |
| *minima* Ulrich | .... | .... | rr | .... | .... | .... |
| *ornata* Ulrich | .... | .... | nr | nr | .... | .... |
| *Monticulipora cincinnatiensis* (James) | .... | .... | .... | g | .... | .... |
| *mammulata* D'Orbigny | r | nr | cc | .... | .... | .... |
| *Nicholsonella vaupeli* (Ulrich) | .... | .... | r | .... | .... | .... |
| *Peronopora compressa* (Ulrich) | .... | .... | c | c | c | c |
| *decipiens* (Rominger) | .... | .... | .... | c | c | c |
| *vera* Ulrich | c | .... | .... | .... | .... | .... |
| *Petigopora asperula* Ulrich | .... | .... | nr | nr | .... | .... |
| *offula* Ulrich and Bassler | .... | .... | .... | .... | .... | c |
| *gregaria* Ulrich | .... | r | r | r | .... | .... |
| *petechialis* Nicholson | c | c | c | c | c | c |
| *Phylloporina clathrata* (Miller and Dyer) | .... | r | .... | .... | .... | .... |
| *variolata* (Ulrich) | r | .... | .... | .... | .... | .... |
| *Proboscina auloporoides* (Nicholson) | .... | .... | c | nr | .... | .... |
| *frondosa* (Nicholson) | .... | ....? | c | c | c | c |
| *Rhopalonaria venosa* Ulrich | .... | .... | .... | .... | .... | r |
| *Spatiopora aspera* Ulrich | .... | r | .... | .... | .... | .... |
| *lineata* Ulrich | .... | r | .... | .... | .... | .... |
| *maculosa* Ulrich | .... | r | .... | .... | .... | .... |
| *Stigmatella dychei* (James) | .... | .... | .... | .... | .... | g |
| *nicklesi* Ulrich and Bassler | .... | g | .... | .... | .... | .... |
| *Stomatopora arachnoidea* (Hall) | c | c | c | c | c | c |
| *delicatula* (James) | .... | .... | .... | nr | r | .... |
| *inflata* (Hall) | .... | nr | c | c | c | .... |
| *Vinella radialis* Ulrich | .... | .... | .... | rr | .... | .... |

### Subdivisions of the Maysville.

MOUNT HOPE BEDS.—These appear to be more fossiliferous in Kentucky than in Ohio. At nearly all Kentcuky localities on the flanks of the anticline the *Strophomena maysvillensis* Foerste appears at or near the base of the Mount Hope and ranges upward into the Fairmount. At Newport and Covington the upper Eden fauna persists in part for a few feet, but soon gives way to the new fauna, though a few of the upper Eden forms survive somewhat longer. Among these survivors are *Amplexopora septosa, Peronopora vera, Constellaria prominens,* and *Callopora nodulosa.* A species of *Batostoma* described later in this paper, rare at Cincinnati, is abundant at Maysville. Several closely allied species of *Heterotrypa* are among the newcomers in the fauna. In the northern area a small species of *Platystrophia* makes its appearance. No Platystrophias have been noted in the Eden. Other bryozoa are *Callopora subplana, Callopora dalei* and *Constellaria plana.*

The only exposures from which fossils were collected were in the Maysville section and in railroad cuts between Million and Richmond in Madison county.

FAIRMOUNT BEDS.—These beds are very fossiliferous in Kenton and Campbell counties, a greater variety of fossils having been found in them than in any other subdivision of the Cincinnatian. Among the commoner forms, though these are apt to be gregarious, may be mentioned *Dalmanella bellula* (James), *Dalmanella meeki* (Miller), *Platystrophia crassa* (James), *Plectorthis ? ella* (Hall), *Plectorthis plicatella* (Hall), *Plectorthis triplicatella* (Hall), *Rafinesquina squamula* (James), *Shizocrania filosa* Hall and Whitfield, *Strophomena planoconvexa* Hall (in a limited horizon at the base), and *Cyclonema* several species. Among the common bryozoa are *Heterotrypa* several species, *Constellaria florida* Ulrich, *Amplexopora discoidea* (Nicholson), *Atactoporella multigranosa* (Ulrich),

*Atactoporella mundula* (Ulrich), *Callopora dalei* (Edwards and Haime), *Ceramoporella ohioensis* (Nicholson), *Crepipora simulans* Ulrich, *Dekayia aspera* Edwards and Haime, *Discotrypa elegans* (Ulrich), *Escharopora falciformis* (Nicholson), *Escharopora maculata* Ulrich, *Escharopora pavonia* (D'Orbigny), *Homotrypa curvata* Ulrich, *Homotrypa cincinnatiensis* Bassler, *Homotrypa obliqua* Ulrich, and *Monticulipora mammulata* D'Orbigny.

From Maysville south and similarly on the west side of the anticline, the Fairmount beds are very much less fossiliferous than farther north. Many layers seem destitute of fossils. At Maysville just at the top of the Fairmount in a two or three inch layer of clay is a pocket of *Pasceolus ? claudii* Miller and *Pasceolus ? darwini* Miller. This is the only locality where these problematical organisms have been found in abundance. In the Maysville section somewhat above the middle of the Fairmount occurs a heavy massive layer, 15 to 20 inches thick, with a peculiar concretionary structure; the upper surface is level while the under side has a rounded, billowy appearance.

Exposures of the Fairmount beds were examined in the Maysville section; along the railroad between Million and Richmond; near Day's Mill on the Licking river in Fleming county; in railroad cuts and in quarries in the vicinity of Mt. Sterling; and on a branch of Caney Creek near Lebanon.

BELLEVUE BEDS.—At Cincinnati the Bellevue marks the transition from the Fairmount to the Corryville. It has a thickness of only 10 to 15 feet, but a distinctive fauna. Of a rather peculiar lithologic character, it resists erosion better than the overlying and underlying strata and is often seen as an overhanging or projecting cliff in old abandoned quarries on the hill sides. South and southwest of Covington it forms the capping of the hills. At Cincinnati and vicinity the layers seem to be almost made up of the remains of a vigorous bryozoan fauna. At Maysville

they have still something of this character, but are reduced in thickness. Almost no exposures of any consequence were met farther south, but it is probable that they change materially and they may not be distinguishable from the overlying layers. The *Monticulipora molesta* Nicholson (=*Monticulipora mammulata* D'Orbigny, probably) is very common in these beds at Cincinnati and at Maysville. It is not restricted to the Bellevue for it occurs rather rarely, as a somewhat massive form, in the lower part of the Fairmount (it is to this form that the name *M. mammulata* has been supposed to belong), and in the upper part of the Fairmount rather abundantly as a frondescent form.

Corryville beds.—The highest hills back of Covington are probably crowned by the lowest layers of these beds, but they are seldom exposed here. They have been studied chiefly at Cincinnati where they are very fossiliferous. At Maysville they are much less so, while near Richmond, Ky., they are decidedly barren in large part. Here also they are in part cherty. On the east side of the anticline the only exposures seen were in the Maysville section and near Richmond. On the west side, exposures, showing only a few feet vertically, were seen in Bullitt county, near High Grove; in Washington county east of Fredericktown; at Springfield; and near Lebanon. The fossils collected have not yet been examined.

Mount Auburn beds.—The large brachiopod *Platystrophia lynx* characterizes these beds in Ohio. There they have a thickness of about 20 feet. They are less regularly bedded than the underlying Corryville or the overlying Arnheim. In exposures they present a somewhat scraggy appearance. They cap the highest hills around Cincinnati, but on the south side of the Ohio river they have been entirely removed by erosion. They are found on both east and west sides of the anticline in Kentucky, and present about the same appearance as in Ohio and Indiana. The fauna has the same general aspect in all these

areas, with about the same elements, though the bryozoa present species in each of the areas not found in the others. The *Platystrophia lynx,* in Kentucky as in Ohio and Indiana, is more abundant in these beds than in any other subdivision of the Maysville group. Quite a varied fauna has become known, but it is still largely undescribed.

The principal exposures seen on the east side of the anticline were in the Maysville section; near Sunset in Fleming county; and near Richmond; on the west side, in Spencer county, a short distance north of High Grove; and at several points in the vicinity of Lebanon in Marion county. At these last exposures the Mount Auburn was overlain by Devonian limestone.

ARNHEIM BEDS.—The name Warren was first applied to these beds, as they form the surface rock to a large extent in Warren county, Ohio, where they were first studied. As the name Warren had been applied earlier to a Devonian formation in Pennsylvania, Foerste has substituted the name Arnheim from a locality in Brown county, Ohio, where a good section can be studied. Blue shales and limestone are the prevailing materials. The beds have not been thoroughly studied yet, even in Ohio, and the fauna is mostly undescribed. At one horizon, quite limited vertically, but very extended horizontally, as shown by the large number of localities in Ohio and Indiana from which it has been reported, the *Dinorthis carleyi* Hall (usually, but in the writer's opinion erroneously, considered a synonym for *Dinorthis retrorsa* Salter) occurs. This fossil has not yet been found in Kentucky, so far as our information goes, but it probably will be. In Ohio the Arnheim beds have been reported to be about 80 feet thick. No opportunity offered for measuring their thickness in Kentucky. In Ohio the upper few feet consist of a concretionary, rubbly, indurated clay. In Kentucky the last few feet are quite different and usually highly fossiliferous. *Batostoma varians* is a common form both in Kentucky and Ohio.

The principal exposures seen on the east side of the anticline were in the Maysville section, about five miles south of Maysville; on the east side of the Licking river in Fleming county, near Wyoming; and in a number of railroad cuts west of Richmond and for several miles east; on the west side of the anticline near Mt. Washington in Bullitt county; north of High Grove in Spencer county; in Nelson county; on the Bardstown pike near Cox's creek; and in Washington county about five miles west of Springfield.

### Richmond Group.

With the close of the Maysville, the period of uniformity over wide areas in the interior region during Cincinnatian times ceases. The Richmond shows very much more difference geographically than the Winchester, Eden, or Maysville. The faunas are more limited horizontally, an evidence that the sea had been filling up to such an extent that here and there barriers of various kinds were formed which restricted the free movements of animal life which had prevailed before this time. These barriers were, in part, shoal places over which the waves moved with violence, thus destroying the quiet conditions necessary for exuberance of life. In some places portions may even have projected a little above the surface of the sea, particularly in late Richmond time. Probably also sediment-laden currents from land surfaces which had emerged at no great distance produced areas in which the conditions were inimical to most forms of life.

In the Ohio--Indiana area conditions were usually propitious for animal life. A large and varied fauna has been made known, in which bryozoa and brachiopods predominate. The list of bryozoa thus far described is here given as some of these forms are known to occur in Kentucky and others will probably be found. A very large number of species is known from all three

of the States Kentucky, Indiana and Ohio, awaiting description. Of all the bryozoa in the following list only one species has been described from Kentucky material, the *Homotrypa nicklesi* Bassler, collected by the writer near Raywick in Marion county in 1888:

## LIST OF RICHMOND BRYOZOA.

| | Waynesville | VERSAILLES | | Saluda |
|---|---|---|---|---|
| | | Liberty | Whitewater | |
| *Amplexopora pustulosa* Ulrich | r | | | |
| *Atactopora angularis* Ulrich and Bassler | rr | | | |
| *Atactoporella schucherti* Ulrich | r | | | |
| *Batostoma variabile* Ulrich | | | | c |
| *varians* James | c | | | |
| *Bythopora meeki* (James) | cc | | | |
| *Callopora subnodosa* Ulrich | c | | | |
| *Calloporella circularis* (James) | | r | | |
| *Ceramoporella distincta* Ulrich | c | | | |
| *ohioensis* (Nicholson) | c | c | c | |
| *Constellaria limitaris* (Ulrich) | r | | | |
| *polystomella* Nicholson | r | r | r | |
| *Cyphotrypa stidhami* (Ulrich) | | | | c |
| *Eridotrypa simulatrix* (Ulrich) | c | | | |
| *Fenestella granulosa* Whitfield | | | r | |
| *Graptodictya perelagans* (Ulrich) | c | | | |
| *Helopora elegans* Ulrich | | | r | |
| *harrisi* James | c | | | |
| *Heterotrypa prolifica* Ulrich | c | c | c | |
| *subramosa* (Ulrich) | c | | | |
| *Homotrypa dawsoni* (Nicholson) | r | | | |
| *flabellaris* Ulrich | c | | | |
| *flabellaris-spinifera* Bassler | c | | | |
| *nicklesi* Bassler | | | | |
| *nitida* Bassler | | | r | |
| *nodulosa* Bassler | r | | | |
| *ramulosa* Bassler | | | r | |
| *richmondensis* Bassler | c | | r | |
| *wortheni* (James) | | | c | |
| *wortheni-intercellata* Bassler | | | | nr |
| *wortheni-prominens* Bassler | | | | nr |
| *Leptotrypa ornata* Ulrich | nr | | | |
| *Lioclemella subfusiformis* (James) | c | | | |
| *Mesotrypa patella* (Ulrich) | | r | | |

LIST OF RICHMOND BRYOZOA—Continued.

| | Waynesville | VERSAILLES | | Saluda |
|---|---|---|---|---|
| | | Liberty | Whitewater | |
| *Monticulipora cleavelandi* (James) | ..... | ..... | c | ..... |
| *epidermata* Ulrich and Bassler | ..... | ..... | c | ..... |
| *lævis* Ulrich | ..... | ..... | c | ..... |
| *lævis-consimilis* Ulrich | ..... | ..... | nr | ..... |
| *parasitica* Ulrich | ..... | ..... | nr | ..... |
| *winchelli* James | ..... | ..... | ..... | ..... |
| *Pachydictya fenestelliformis* (Nicholson) | ..... | g | ..... | ..... |
| *Paleschara beani* (James) | nr | ..... | ..... | ..... |
| *Peronopora decipiens* (Rominger) | c | c | c | ..... |
| *Petigopora petechialis* (Nicholson) | c | ..... | ..... | ..... |
| *Prasopora hospitalis* (Nicholson) | c | ..... | ..... | ..... |
| *Proboscina frondosa* (Nicholson) | nr | ..... | ..... | ..... |
| *Ptilodictya flagellum* Nicholson | rr | ..... | ..... | ..... |
| *magnifica* Miller | ..... | ..... | r | ..... |
| *nodosa* James | r | ..... | ..... | ..... |
| *plumaria* James | ..... | ..... | r | ..... |
| *Rhinidictya lata* (Ulrich) | nr | ..... | ..... | ..... |
| *Rhombotrypa quadrata* (Rominger) | cc | cc | cc | ..... |
| *subquadrata* Ulrich | ..... | nr | ..... | ..... |
| *Rhopalonaria venosa* Ulrich | nr | ..... | ..... | ..... |
| *Spatiopora corticans* (Nicholson) | r | ..... | ..... | ..... |
| *montifera* Ulrich | r | ..... | ..... | ..... |
| *tuberculata* (Edwards and Haime) | r | ..... | ..... | ..... |
| *Stigmatella crenulata* Ulrich and Bassler | nr | ..... | ..... | ..... |
| *interporosa* Ulrich and Bassler | c | ..... | ..... | ..... |
| *personata* Ulrich and Bassler | r | ..... | ..... | ..... |
| *spinosa* Ulrich and Bassler | r | ..... | ..... | ..... |
| *Stomatopora arachnoidea* (Hall) | c | c | c | ..... |
| *delicatula* (James | nr | ..... | ..... | ..... |

WAYNESVILLE BEDS OR LOWER RICHMOND.—On stratigraphical grounds mainly these beds in Kentucky are considered the southward extension of the Ohio and Indiana Waynesville. In Ohio and Indiana the lower Richmond is very fossiliferous, both the clay beds which are often quite thick, and the limestone beds. In Kentucky a clay, often somewhat sandy, predominates and the formation, with the exception of layers here

and there, is comparatively unfossiliferous. This may have been due to something in the material of sedimentation or to conditions prevailing which were inimical to animal life. *Prasopora hospitalis* appears to be the commonest bryozoan and is found on both the eastern and western sides of the anticline.

The only exposures examined on the east side of the anticline were along the road leading into Owingsville from the south; on the east side of the Licking river in Fleming county, near Wyoming; one mile west of Sunset in Fleming county; and the top of the Maysville section about five miles south of Maysville. None of the exposures were very satisfactory and fossils were not abundant, perhaps due, in part at least, to the character of the exposure. On the west side of the anticline, several exposures were examined in Bullitt county in the vicinity of Mt. Washington; in Nelson county; in Washington county, five miles west of Springfield; and in Marion county in the vicinity of Lebanon.

VERSAILLES BEDS OR MIDDLE RICHMOND.—In Wayne and Fayette counties in Indiana and the adjoining counties of Ohio, the middle Richmond is easily separable into two divisions, to which the names Liberty and Whitewater have been given; but farther south in Indiana and thence into Kentucky as pointed out by Foerste,[12] and with this the writer's observation agrees, the lithologic characters and the faunas lose their distinctiveness. For this reason Foerste has proposed to call the middle Richmond the Versailles beds. This term will be used in this report. The short time allotted to the fieldwork did not permit the making of detailed sections nor the determining with any degree of accuracy of the boundary lines between the subdivisions of the Richmond in Kentucky. An old coral reef is found in the middle Richmond around Bardstown, but its exact posi-

[12]Science (new ser.) 22, p. 150, 1905.

tion and extent have not been determined. The few exposures of Versailles seen yielded comparatively few fossils. These have not yet been examined.

No exposures were visited on the east side of the anticline. On the west side exposures were examined north of Mt. Washington; about five miles south of Mt. Washington near Salt river; one mile west of Bardstown; and at the top of the Wheatley's branch section, five miles west of Springfield.

SALUDA BEDS OR UPPER RICHMOND.—The upper beds of the Richmond vary a great deal in Ohio and Indiana, much more than those of the middle Richmond, proof that the conditions produced by shallowing seas at the south had made their way northward. At Madison, Indiana, where the Saluda, then called Madison bed, first received study, it is a massive, banded rock. Farther north in Indiana it becomes more shaly, with some limestone. In Ohio, in the region of Dayton, it contains a large amount of marly clay. This is even more strongly its character farther east, as in Clinton county. Exposures are rather rare in Ohio as it soon forms slopes which become covered by vegetation. In Kentucky on the western side of the anticline it is usually a sandy clay, sometimes becoming massive, in which fossils are rare or wanting. It is found here only in places. Whether the Saluda was deposited all over the region or only in parts remains to be determined. Various beds of Silurian and Devonian age are found resting upon upper or middle Richmond or even lower beds, indicating a complex history. Extended study will be required to decipher the details of this history. Whether similar conditions prevailed on the east side of the anticline, as is probable, can not be affirmed, as no opportunity offered for visiting localities in this region showing Saluda beds.

Only one exposure of the Saluda was examined. It was at the top of the Floyd's creek section about two miles north of Mt. Washington.

## Description of Species.

Only a few of the commoner and more characteristic species are here described. An idea of the luxuriance of the bryozoan fauna of the Cincinnatian period has been given by the lists included in preceding pages. A large number of new species remain to be described from the material now in hand, but their determination will require extended study and the preparation of numerous sections. It was intended to give illustrations to elucidate the interior structure, particularly of the new species described, but the necessary drawings could not be prepared for lack of time. These illustrations will be given at some future time. All the figures on the plates are natural size. They have been produced by photographic process. For this work the writer is indebted to Dr. Aug. F. Foerste.

### 1. From the Lexington Group.

PRASOPORA SIMULATRIX ULRICH.

Plate 1, fig. 1.

Prasopora simulatrix. Ulrich, Fourteenth Ann. Rept. Geol. and Nat. Hist. Surv. Minnesota, p. 85, 1886. Geol. Minnesota, vol. 3, p. 245, pl. xvi, 1-10, 1893.

Zoarium discoid at first, with growth becoming hemispheric or subconical; very large specimens show lobes and other irregularities. Base usually concave, with a striated and concentrically wrinkled epitheca. Height of zoarium from 5 to 50 mm. or more; diameter from 10 to over 100 mm. Zoœcia with direct, subcircular apertures, about 11 in 3 mm., and thin walls; at the angles of junction are small, angular mesopores. Clusters of larger zoœcia have their centers about 4 mm. apart. No acanthopores. Internally the zoœcia have a large number of cystiphragms in overlapping series, and diaphragms.

Occurrence:—Very common in the Lexington group at Frankfort and numerous other localities. The discoid or hemispheric form and rather large cells easily distinguish this form from associated bryozoa.

### CALLOPORA MULTITABULATA (ULRICH).

Plate 1, fig. 2.

Monotrypella multitabulata. Ulrich, Fourteenth Ann. Rept. Geol. and Nat. Hist. Surv. Minnesota, p. 190, 1886.

Callopora multitabulata. Ulrich, Geol. Minnesota, vol. 3, p. 280, pl. xxiii, 11, 12, 16, 17, 24-26, 30, 31, 1893.

Zoarium subcylindrical, branching rather irregularly, from 2 to 10 mm. in diameter, usually about 7 or 8 mm. Surface with more or less strongly elevated monticules, 2.5 mm. apart from center to center. Mesopores few, scarcely seen at the surface, the angular, thin-walled zoœcia being in contact with each other. Apertures direct, about 11 in 3 mm. Diaphragms exceedingly abundant throughout the zoœcial tubes, very much crowded in the peripheral region.

Occurrence:—Common in the Lexington group at Frankfort and numerous other localities in Kentucky. The cylindrical, branching form and the rather large, elongated cell apertures serve to distinguish this form from associated bryozoa.

### DEKAYELLA TRENTONENSIS (ULRICH).

Plate 1, fig. 3.

Dekayella trentonensis. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 6, p. 151, pl. vi, 6, 6a, 1883. Geol. Minnesota, vol. 3, p. 274, 1893.

Zoarium dendroid; branches compressed, dividing frequently and rather irregularly, from 4 to 10 mm. in width. Surface smooth, or with low, rounded monticules 2.5 mm. apart; occupied by clusters of cells a little larger than the average, with occasionally a few mesopores at their summits. Apertures subangular, about 9 in 2 mm.; interspaces rather thick. Acanthopores large and prominent, when preserved, about 6 or 7 in 3 mm. Zoœcia with thin, slightly flexuous walls in the axial region and with diaphragms 2 to 4 times their diameter apart; as they curve gently into the mature region, the walls thicken, and diaphragms become much more numerous.

Occurrence:—In the Lexington group at Frankfort and other localities in central Kentucky, associated with the two preceding species.

## 2. From the Winchester Group.

### Eridotrypa briareus (Nicholson).

Plate 1, figs. 4, 5.

Zoarium a branching stock from a pointed base; branches smooth, cylindrical, from 3 to 8 mm. in diameter, and given off at an acute angle. Apertures oval, rather thick-walled, usually oblique to the surface, about 7 in 2 mm. Apertures of rather larger size occur in clusters which are not raised above the general surface level. Zoœcia thin-walled and polygonal in the axial region; walls thickened in the peripheral region. Diaphragms present, particularly in the transition zone, *i. e.* where the zoœcia change from the immature to the mature state. Few mesopores and no acanthopores developed.

Occurrence:—A common and characteristic form of the Winchester group. The original specimen, from which Professor Nicholson drew up his description and which is rather exceptional in the large number of branches it developed in a short space, came from the river bank at Covington, Ky. The species occurs abundantly at Covington, Moscow, Falmouth, Lair, Pleasant Valley, Winchester and Lexington, Ky., and at Point Pleasant, Ohio. The pointed base distinguishes it at once from associated forms. The branches may be known by their smooth surface and the commonly oblique apertures.

### Peronopora milleri n. sp.

Plate 1, fig. 6.

Zoarium consisting of bifoliate, flat or undulated fronds, varying from 1 to 3 mm. in thickness; height and breadth unknown as only incomplete examples have been found, which measure several cm. in height and breadth. Occasionally branches which are themselves bifoliate fronds, grow at right angles to the parent frond, and in like manner from these branches others may grow. Surface smooth; the clusters of slightly larger apertures scarcely raised above the general level.

Apertures circular, thin-walled, about 7 in 2 mm., surrounded by the very numerous openings of mesopores. The interspaces carry a very large number of small acanthopores. Zoœcia have a very short immature region in which very large cystiphragms are developed; they soon proceed at almost right angles to the surface. In the mature region the cystiphragms are smaller and form an interrupted series, and diaphragms are few or wanting. The mesopores have closely set diaphragms.

Occurrence:—The material from which the description is drawn was collected on the outskirts of Lexington, Ky., from the Winchester group. The specific name is in honor of Professor Arthur M. Miller. The small size and thin walls of the apertures, the very numerous mesopores, which surround the apertures, and the very numerous, small acanthopores, distinguish this species from an associated species of *Peronopora* which has not yet been described. The *Peronopora vera* from overlying Eden has very much larger cells.

### Constellaria emaciata Ulrich and Bassler.

Plate 1, figs. 7, 8.

Constellaria florida var. emaciata Ulrich and Bassler. Hayes and Ulrich, Geol. Atlas of U. S., Columbia folio, no. 95, Illustration sheet, fig. 30, 1903.
Constellaria florida var. emaciata n. var. Ulrich and Bassler, Smithsonian Miscellaneous Collections, vol. 34, 1904, p. 37.

Zoarium consisting of small fronds, or of rounded or compressed branches, about 3 mm. in thickness and from 4 to 7 mm. in breadth, and from 15 to 30 mm. in height. Division occurred at short, irregular intervals, and an entire zoarium consisted of a small clump of closely interwoven narrow branches. The surface is marked by small, stellate maculæ, usually well elevated, each consisting of from 5 to 8 narrow ridges radiating from a center. Apertures with a narrow, distinctly marked rim. Mesopores very numerous, especially between the stellate maculæ. The zoœcia have diaphragms about 3 tube diameter apart. The mesopores are closely tabulated.

Occurrence:—A very common form in the Winchester group. Specimens were collected from Lexington, Winchester, Pleasant Valley, Lair and other points. The Kentucky examples form wider fronds on the whole than the Tennessee forms, upon which this species or variety is based, but seem to differ in no essential particular. The Tennessee forms are stated to occur at the top of the Bigby limestone at Columbia, Tenn., and in the shaly parts of the Catheys limestone.

### HOMOTRYPELLA NORWOODI N. SP.

Plate 1, figs. 9-11.

Zoarium ramose, branching at variable intervals; consisting of rounded or compressed branches from 3 to 6 mm. thick and from 4 to 12 mm. wide. Surface with small, conical monticules, about one-half mm. in diameter at their bases, and 2 mm. or somewhat less apart measuring from summit to summit. Apertures subpolygonal, all of about the same size, from 12 to 14 in 2 mm., often indented by the numerous small acanthopores. No mesopores detected. Zoœcia with thin, somewhat flexuous walls, and rather distant diaphragms in the immature region; they bend rather abruptly to the mature region, where they have their walls lined by a linear series of small, overlapping cystiphragms. In this region also diaphragms are from 2 to 4 times their diameter apart.

Occurrence:—Occurs abundantly in the Winchester group near Pleasant Valley, in Carlisle county. The specific name is given in honor of Professor Charles J. Norwood, Director of the Kentucky Geological Survey.

### HETEROTRYPA PARVULIPORA ULRICH AND BASSLER.

Plate 1, fig. 12.

Heterotrypa parvulipora Ulrich and Bassler. Hayes and Ulrich, Geol. Atlas of U. S., Columbia folio, no. 95, Illustration sheet, fig. 26, 1903.

Heterotrypa parvulipora n. sp. Ulrich and Bassler, Smithsonian Miscellaneous Collections, vol. 47, p. 26, pl. xi, 4-6, 1904.

Zoarium forming large, flabellate expansions from 10 to 15

mm. in thickness. Surface smooth; maculæ not a prominent feature, often scarcely distinguishable. Apertures small, angular, thin-walled, about 10 in 2 mm. In the immature region the zoœcia have thin, somewhat wavy walls and diaphragms from one to three times their diameter apart; in the mature region the walls are thickened and diaphragms are much more closely set, becoming as frequent as two to a tube diameter. Mesopores few. Acanthopores small, generally few, but sometimes each angle of junction is occupied by one.

Occurrence:—This species is found at most localities in Kentucky where the Winchester is exposed. The species was first described from material derived from the Catheys limestone in Maury county, Tenn.

### 3. From the Eden Group.

PERONOPORA VERA ULRICH.

Plate 2, fig. 1.

Peronopora vera. Ulrich, American Geologist, vol. 2, p. 40, 1888.

Zoarium consisting of bilaminar fronds, from 2 to 6 mm. thick and 10 or more cm. in height. Fronds usually somewhat undulating and occasionally producing fronds at right angles. Some specimens branch rather frequently, others rarely. Surface smooth, except for clusters of larger cells which sometimes rise a little above the general level. Apertures circular, 7 or 8 of the ordinary size in 2 mm. Apertures in the clusters considerably larger than the others. Usually a large number of circular or subangular mesopores occupy the rather wide interspaces as well as the angles of junction. Often the center of a cluster is occupied with a large number of mesopores. In some specimens few mesopores are present. Occasionally a specimen shows a large number of small acanthopores at the surface, and these may also be seen in some sections. Zoœcia have a very short immature region; in the mature region they have a linear series of overlapping cystiphragms and a few diaphragms.

Occurrence:—A very common form throughout the Eden in Ohio and Kentucky. It also ranges well up into the Mount Hope beds of the Maysville group. The examples studied by sections were collected in the vicinity of Cincinnati, Ohio.

### AMPLEXOPORA PERSIMILIS N. SP.

Plate 2, figs. 2, 3.

Zoarium ramose, branching at variable intervals, usually by bifurcation. Branches from 4 to 15 mm. in diameter, often somewhat flattened. Surface smooth except for the low rounded monticules, which occasionally become conspicuous. Apertures with thin interspaces, polygonal, indented by the very numerous small acanthopores when the zoarium is in a fine state of preservation, 7 or 8 in 2 mm.; those in the monticules a little larger than the others. Zoœcia thin-walled in the immature region, with rather thin distant diaphragms; in the mature region the walls are but little thickened and the zoœcia continue to be prismatic. In this region diaphragms vary in their distance apart, ranging from 1 to 3 in the space of a tube diameter.

The description given above applies to what is considered the typical form. The species is exceedingly abundant and shows a great deal of variation, more especially in the size and number of the acanthopores, and size of zoarium, which may be several times as large as the dimensions given above indicate. There is also some variation in the size of the apertures.

Occurrence:—Very abundant in the lower two-thirds of the Eden group at Cincinnati, Ohio, Covington and Newport, Ky. The typical form was collected from the lower Eden in the west part of Covington near the bank of the Ohio river.

### DEKAYELLA ULRICHI (NICHOLSON).

Plate 2, fig. 4.

Chætetes Fletcheri. Nicholson, Paleontology of Ohio, vol. 2, p. 197, pl. xxi, 7, 7a, 1875.

Monticulipora (Heterotrypa) Ulrichii. Nicholson, Genus Monticulipora, p. 131, fig. 22, 1881.

Dekayella ulrichi. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 6, pp. 91, 153, 1883.

Zoarium ramose, branches cylindrical, dividing dichotomously or sometimes otherwise, from 4 to 8 mm. on the average in diameter. Surface smooth. Apertures circular, about 8 in 2 mm. Mesopores usually numerous. Acanthopores numerous, giving to the surface a spinous appearance when they are preserved. Zoœcial tubes thin-walled, with few diaphragms axially; walls thickened and diaphragms numerous peripherally. Mesopores with closely set diaphragms.

Occurrence:—Common in the middle and upper portions of the Eden in northern Kentucky and in Ohio.

### HETEROTRYPA FOERSTEI N. SP.

Plate 2, fig. 5.

Zoarium frondescent, from 3 to 7 mm. in thickness, and 15 to 49 or more mm. in width, and 30 to 60 or more mm. in height. Surface smooth, except for slightly elevated monticules composed of apertures scarcely larger than the others. Apertures polygonal, thin-walled, 8 or 9 in 2 mm. Mesopores very few. Acanthopores situated at the angles of junction, not conspicuous, and rather less numerous than the apertures. Zoœcia with thin walls in the immature region, which are but little thickened in the mature region. Diaphragms wanting in the immature region, from 1 to 2 in the space of a tube diameter in the mature region. Mesopores developed only in the mature region, with closely set diaphragms. On account of their fewness, mesopores are rarely cut in vertical sections.

Occurrence:—Collected by Dr. Aug. F. Foerste, in whose honor the specific name is given, from the lower Eden exposed in railroad cuts along the Queen & Crescent route near Rogers Gap, in Scott county, Ky.

### BATOSTOMA IMPLICATUM (NICHOLSON).

Plate 2, fig. 6.

Monticulipora (Heterotrypa) implicata. Nicholson, Genus Monticulipora, p. 147, pl. ii, 7-7e, 1881.

Zoarium dendroid, consisting of flattened stems, from 3 to

5 mm. in thickness and from 2 to 4 times as much in breadth, rising from a basal expansion which encrusts other organisms. Surface smooth, hirsute from the projecting acanthopores when these are preserved. Apertures irregularly oval, often indented by the strong acanthopores, 6 or 7 in 2 mm. In the immature region the zoœcia have thin walls, and few diaphragms; in the mature region the walls are much thickened, and diaphragms more numerous. A considerable number of mesopores interspersed among the zoœcia. Acanthopores very large and prominent, situated at the angles of junction and between the walls.

Occurrence:—A very abundant form in the Eden. Collected at Newport and Covington, Ky., and Cincinnati, Ohio.

### Crepipora venusta (Ulrich).

Plate 2, fig. 7.

Chætetes venustus. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 1, p. 93, pl. iv, 7, 7a, 1878.

Crepipora venusta. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 5, p. 257, 1882.

Zoarium consisting of hollow branches, bifurcating, or branching otherwise, at variable intervals, growing from a broad expansion which is covered on the lower side by a heavy, strongly wrinkled epitheca. Branches from 6 to 20 mm. in diameter, the hollow part usually filled with clayey material. The basal epitheca continues up into the branches. Substance of zoarium surrounding the hollow part from 2 to 5 mm. thick. Surface smooth, marked with maculæ, composed of from 30 to 80 minute tubuli (mesopores ?). Apertures subpolygonal, with thin interspaces; lunarium not very conspicuous, its ends projecting slightly from the walls. Zoœcia with diaphragms from 1 to 2 times their diameter apart. Mesopores with closely set diaphragms.

Occurrence:—Lower Eden at Covington, Ky. Also collected by Dr. Aug. F. Foerste at Rogers Gap, Ky.

### CALLOPORA NODULOSA (NICHOLSON).

Plate 2, figs. 8, 9.

Chætetes nodulosus. Nicholson, Paleontology of Ohio, vol. 2, p. 200, pl. xxi, 10, 10a, 1875; Annals and Magazine of Natural History, ser. 4, vol. 18, p. 87, pl. v. 3, 1876;

Monticulipora (Heterotrypa) nodulosa. Nicholson, Genus Monticulipora, p. 116, pl. i, 4-4d, 1881.

Zoarium ramose, of small, cylindrical, dichotomously branching stems, from 1.5 to 3 mm. in diameter. Surface with numerous prominent conical monticules about 1 mm. apart. Apertures oval, with their longer diameter in the direction of the branch, about 6 in 2 mm., measuring longitudinally. Mesopores numerous. Zoœcia with thin walls and few diaphragms in the axial region; the latter become more numerous and the walls are thickened as the surface is approached. Mesopores with closely set diaphragms.

Occurrence:—Common in the upper Eden in Ohio and northern Kentucky; a somewhat more robust form occurs in the lower Mount Hope beds of the Maysville group in the same area.

### CALLOPORA SIGILLARIOIDES (NICHOLSON).

Plate 2, figs. 10, 11.

Chætetes sigillarioides. Nicholson, Paleontology of Ohio, vol. 2, p. 203, pl. xxii, 9, 9a, 1875; Annals and Magazine of Natural History, ser. 4, vol. 18, p. 87, pl v, 2, 1876.

Monticulipora (Heterotrypa) O'Nealli (not of James). Nicholson, Genus Monticulipora, p. 118, pl. iii, 3-3f, 1881.

Zoarium ramose, consisting of small, dichotomously dividing branches, from 2 to 4 mm. in diameter. Surface smooth, except for scarcely elevated clusters of larger cells. Apertures oval, their long axes in the direction of the branch, about 6 in 2 mm., measuring longitudinally, and 8 in 2 mm. transversely. Among the apertures are the circular openings of a considerable number of mesopores. Diaphragms few in the axial region, rather numerous in the mature region. The mesopores have closely set diaphragms.

Occurrence:—Common in the Eden formation in Ohio and Kentucky.

## 4. From the Mount Hope Beds.

### HETEROTRYPA SUBPULCHELLA (NICHOLSON).

Chætetes subpulchellus. Nicholson, Paleontology of Ohio, vol. 2, p. 196, pl. xxi, 6, 6a, 1875.

Monticulipora (Heterotrypa) subpulchella. Nicholson, Genus Monticulipora, p. 134, fig. 23 and pl. v. 2, 2a, 1881.

Zoarium of rather narrow, branching fronds, from 2 or 3 to 5 or 6 mm. thick, and 50 or more mm. in height. Surface smooth. Apertures circular or subpolygonal, 8 or 9 in 2 mm., with many mesopores interspersed, the latter also clustered into somewhat stellate groups or maculæ, about 2 mm. apart. In the axial region the zoœcia are thin-walled, and with comparatively few diaphragms; in the mature region, the walls are thickened, the diaphragms numerous, and medium-sized acanthopores developed in considerable numbers. Mesopores with closely set diaphragms.

Occurrence:—Very abundant and one of the characteristic forms, in the Mount Hope beds of the Maysville group. Found at Covington and Newport, Ky., Cincinnati, Ohio, and Maysville, Ky.

### BATOSTOMA MAYSVILLENSIS N. SP.

Plate 2, figs. 13, 14.

Zoarium irregularly ramose, branching variably. Branches cylindrical, or sometimes compressed, 3 to 10 mm. in diameter. Surface smooth, with clusters of apertures slightly larger than the average, sometimes rising a little above the general level. Apertures aubangular or subcircular, with sometimes rather thin, at other times somewhat thickened, interspaces, about 6 in 2 mm. Mesopores wanting or almost so. No acanthopores were detected either on the surface or in sections. Their absence may be due to the state of preservation of the material examined; better material may show them to have been present. Zoœcia

are somewhat irregular in their course, thin walled and without diaphragms in the axial region; in the mature region they have well-developed, ring-like walls, and diaphragms varying from 2 to 3 or 4 in the space of two tube diameters.

Occurrence:—Very abundant in the Mount Hope beds of the Maysville group near Maysville, Ky. Also occurs, but much less abundantly, in the same beds at Cincinnati, Ohio.

### CONSTELLARIA PROMINENS ULRICH.

Plate 2, fig. 15.

Constellaria florida var. prominens Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 6, p. 269, pl. xiv, 3, 1883.

Zoarium somewhat variable in form, ranging from cylindrical to frondescent, 3 or 4 to 6 mm. in diameter or thickness, and up to 12 or 15 mm. in breadth, and may attain a height of 100 mm. or more. Surface marked by prominent stellate areas, with a more or less regular arrangement in rows, 2 to 2.5 mm. in diameter and 3 mm. apart from center to center. These consist of a depressed central space, surrounded by from 5 to 9 prominent and radially arranged, elevated ridges occupied by circular apertures, with a small but distinct rim. The depressed portion of the stellate area and the interspaces between the apertures occupied by the very numerous mesopores which may be closed at the surface. Zoœcial tubes with thin walls, which are somewhat thickened in the peripheral region, and few diaphragms. Mesopores with closely set diaphragms. No acanthopores.

Occurrence:—A common form in the Mount Hope beds in Kentucky and Ohio. It is also found in the upper Eden at Newport and Covington, Ky., and Cincinnati, Ohio.

### AMPLEXOPORA SEPTOSA (ULRICH).

Plate 3, fig. 1.

Atactopora septosa. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 2, p. 125, pl. xii, 7-7c, 1879.

Zoarium ramose, from an expanded base attached to various objects, and branching usually at short intervals. Branches

cylindrical, from 5 or 6 to 10 or more mm. in diameter, with low, rounded, rather distant monticules, occupied by apertures somewhat larger than the average. Apertures thin-walled, hexagonal or polygonal, 8 or 9 in 2 mm. Walls beset with numerous acanthopores, which often indent the zoœcial apertures. Diaphragms thin and distant in the axial region; more numerous in the mature region.

Occurrence:—A common form in the upper Eden and in the Mount Hope beds of the Maysville group in the Cincinnati region. The thin-walled, polygonal apertures, often bristling with acanthopores, when the surface is well preserved, are characteristic features of this species.

## 5. From the Fairmount Beds.

ESCHAROPORA HILLI (JAMES).

Plate 3, figs. 2, 3.

Zoarium an unbranched, two-edged, flattened frond, celluliferous on both faces, expanding gradually from a pointed, striated foot which articulated with the socket of an attached base; from 2 to 5 mm. in thickness at the middle, from 6 to 15 mm. wide, and from 30 to 100 mm. in length. Occasionally a specimen is found attaining a breadth of nearly 30 mm. Surface on both sides marked by prominent, transverse ridges, 2 mm. or a little less apart, which are usually continuous across from edge to edge and sometimes a little undulating. Apertures oval or lozenge-shaped, arranged between elevated lines in obliquely diagonal, intersecting series, which are continuous over the ridges; about 8 or 9 in 2 mm. Internal structure about the same as in other species of the genus.

Occurrence:—The two specimens, on opposite sides of a small slab, from which the species was described by Mr. U. P. James, were found on the bank of the Ohio river at Cincinnati. Evidently they had been drifted to that point. This species was afterwards found in considerable abundance by Mr. E. O. Ul-

rich and others in Lincoln and Boyle counties, Kentucky. Examples were collected by the writer during the past summer from the lowest beds of the Fairmount division of the Maysville group in railroad cuts about half way between Million and Richmond, Ky.

### Dekayia aspera Edwards and Haime.

Plate 3, fig. 4.

Dekayia aspera. Edwards and Haime, Polypiers fossiles des Terrains paleozoiques, p. 278, pl. xvi, 2, 2a, 1851.

Dekayia aspera. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 6, p. 148, pl. vi, 5, 1883.

Dekayia attrita. Nicholson, Paleozoic Tabulate Corals, p. 298, pl. xv, 1-1c, 1879.

For full synonymy consult Bulletin of the U. S. Geological Survey, no. 173, p. 228.

Zoarium ramose; branches subcylindrical, from 6 to 12 mm. in diameter. Surface smooth, or with but little elevated maculæ; when well preserved, roughened by the strong acanthopores. Apertures polygonal, with thin interspaces. No mesopores. Zoœcial tubes thin-walled, and with very few diaphragms.

Occurrence:—A common and characteristic form of the Fairmount beds of the Maysville group in northern Kentucky.

### Constellaria florida Ulrich.

Plate 3, fig. 5.

Constellaria florida. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 5, p. 257, 1882; *ibid.*, vol. 6, p. 267, pl. xiv, 2-2f, 1883.

For full synonymy see under Constellaria constellata (Van Cleve) Dana in Bulletin U. S. Geological Survey, no. 173, p. 213, 1900.

This form is so closely like *Constellaria prominens* that a detailed description would be mainly repetition. On the whole, the stellate areas are not so prominent, and are a trifle smaller. In growth it is more truly frondescent.

At the time that the synonymy given in Nickles and Bassler's Synopsis of American Fossil Bryozoa (Bulletin U. S. Geological Survey, No. 173, p. 228) was prepared, the paper by Van Cleve, which appeared in volume 1 of the Proceedings of the

American Association for the Advancement of Science, pp. 19-24, was overlooked. In this paper, a communication presented before the meeting by the secretary, Van Cleve describes his work upon the western zoophytes. Copies of plates of figures which he had prepared were exhibited. Van Cleve's death prevented the publication of his work. A few copies of the plates survived. The illustrations were later reproduced in the Eleventh Annual Report of the Indiana Geological and Natural History Survey, 1882. In the list which Van Cleve gave of forms figured appears "Ceriopora constellata n. sp., blue limestone, Dayton, Ohio." Dana in 1846 established the genus Constellaria, with the remark that a "species of this genus is named Ceriopora constellata on the plates of Western fossils by Van Cleve." Dana gave no locality and mentioned no other species. Hence it was supposed that the common form at Cincinnati, which later passed current as *Stellipora antheloidea* Hall, was the form which Dana and Van Cleve had in view, and so it was concluded that Ulrich's *Constellaria florida* was a synonym. Now that it is known that Van Cleve's material came from the vicinity of Dayton, Ohio, and as it is uncertain that Dana had any specimens before him, Ulrich's name must be regarded as valid. Van Cleve's form is one of the Richmond species of *Constellaria.*

Occurrence:—At Cincinnati, Ohio, and Covington and Newport, Ky., the *C. florida* appears in the middle part of the Fairmount beds of the Maysville group. About 30 or 40 feet intervene between the horizon of *C. florida* and that of *C. prominens,* in which interval no examples of *Constellaria* have yet been found. Examples of the *C. florida* were collected also at Mt. Sterling, Ky.

### Amplexopora cingulata Ulrich.

Plate 3, fig. 6.

Amplexopora cingulata. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 5, p. 254, pl. xi, 5-5c, 1882.

Zoarium ramose, consisting of cylindrical or subcylindrical

branches, which divide dichotomously at irregular intervals, and vary in diameter from 7 to 20 mm. Surface smooth or almost so, with clusters of 7 to 15 larger apertures, which are sometimes a very little elevated above the general level. Apertures polygonal, often somewhat rounded from the thickening of the walls, those in the clusters from 0.4 to 0.5 mm. in diameter, while the others are a little over 0.3 mm. in diameter. Zoœcia thin-walled in the axial region, with diaphragms from two to three times their diameter apart; in the peripheral region, they have the walls much thickened and diaphragms much more numerous. Acanthopores small, very numerous, occupying the angles of junction and occurring also in the space between adjoining zoœcia; only rarely are they seen on the surface; this is probably due to the state of preservation of the material.

Occurrence:—Found abundantly just at the top of the Fairmount beds, about one mile east of Mt. Sterling, Ky. The original material was obtained from McKinney Station in Lincoln county, probably from the same horizon.

### Monticulipora mammulata D'Orbigny.

Plate 3, fig. 7.

Monticulipora mammulata. D'Orbigny, Prodrome de Paleontologie, t. 1, p. 25, 1850.

Chætetes mammulatus. Edwards and Haime, Polypiers fossiles des Terrains paleozoiques, p. 267, pl. xix, 1, 1a, 1851.

Monticulipora (Peronopora) molesta. Nicholson, Genus Monticulipora, p. 224, pl. vi, 2-2d, 1881.

Zoarium irregularly frondescent or sublobate or palmate, rarely submassive; the fronds from 3 to 8 mm. thick, and 30 or 40 cm. high and almost as wide. Surface with closely set, rounded, not conical, often slightly elongated, prominent monticules, from one to two mm. apart. Apertures subequal, even those on the monticules no larger than the others, polygonal, with thin interspaces, about 10 in 2 mm. Mesopores wanting

or practically so. Acanthopores wanting. Zoœcia thin-walled, with very numerous cystiphragms and diaphragms.

Occurrence:—This species appears to begin with the massive form in the lower part of the Fairmount. It becomes abundant in the upper part of the Fairmount and exceedingly abundant in the Bellevue in the vicinity of Cincinnati. In central Kentucky it is abundant in the upper part of the Fairmount. Specimens were collected at Mt. Sterling and Maysville, Ky.

## 6. From the Arnheim Beds.

BATOSTOMA VARIANS (JAMES).

Plate 3, figs. 8, 9.

Chætetes varians. James, The Paleontologist, no. 1, p. 2, 1878.

Monticulipora (Chætetes) varians. James, The Paleontologist, no. 5, p. 36, 1881.

Monticulipora varians. James and James, Jour. Cincinnati Soc. Nat. Hist., vol. 10, p. 177, pl. ii, 4a-b, 1888.

Batostoma variabile (in part). Ulrich, Geological Survey of Illinois, vol. 8, p. 460, pl. xxxv, 4-4e, 5 (not 5a), pl. xxxvi, 1, 1890.

Zoarium variable in form, encrusting, lobate, ramose or subfrondescent. Surface smooth, with scarcely elevated clusters of larger cells. Apertures angular, averaging 6 in 2 mm. Mesopores angular, varying in number, generally few. Acanthopores numerous, usually in the angles between the zoœecia. Zoœcial tubes with thin, slightly flexuous walls and few diaphragms in the axial region; with walls thickened, and several diaphragms in the narrow mature region which the zoœcia enter by a gradual curve.

Occurrence:—Common in the Arnheim (Warren) beds of the Maysville group in Ohio, Kentucky, and Indiana; also abundant in the Waynesville beds of the Richmond in the same area.

## 7. From the Richmond Group.

PRASOPORA ? HOSPITALIS (NICHOLSON).

Plate 3, fig. 10.

Monticulipora (Prasopora) Selwynii var. hospitalis. Nicholson, Genus Monticulipora, p. 209, fig. 45, 1881.

Zoarium when attached forming crusts which grow up into a

conical or hemispheric form, from 3 or 4 mm. to 15 or more mm. in height; when free subglobular or irregularly globose in shape, from 10 to 20 mm. in diameter when adult. Surface smooth except for slightly elevated monticules of larger apertures; often spinulose from the numerous strong acanthopores. Apertures subpolygonal or subcircular, with numerous mesopores in the interspaces, about 8 in 2 mm. Mesopores with closely set diaphragms. Zoœcial tubes rather thin-walled, with numerous cystiphragms and less numerous diaphragms.

Occurrence:—Abundant in the Waynesville beds of the Richmond group in Ohio, Indiana, and Kentucky. In Ohio and Indiana, the attached form is the common one. At Madison, Indiana, and thence south through Kentucky, the free form is the prevailing form.

### Rhombotrypa quadrata (Rominger).

Plate 3, fig. 11.

Chætetes quadratus. Rominger, Proceedings Academy of Natural Sciences of Philadelphia, p. 116, 1866.

Monticulipora (Monotrypa) quadrata. Nicholson, Genus Monticulipora, p. 179, fig. 36, 1881.

Chætetes rhombicus. Nicholson, Paleontology of Ohio, vol. 2. p. 201, pl. xxi. 12, 12a, 1875.

For full synonymy see Synopsis of American Fossil Bryozoa, Bulletin of U. S. Geological Survey, no. 173, p. 318, 1900.

Zoarium ramose, branching frequently as a rule. Branches cylindrical, from 4 to 10 mm. in diameter. Surface smooth. Apertures polygonal, occasionally quite regularly hexagonal and arranged in diagonally intersecting series, from 6 to 8 in 2 mm. In the immature region the zoœcia are thin-walled, and quadrate or rhombic in cross-section; in the mature region the walls are somewhat thickened and several diaphragms are developed. Neither mesopores nor acanthopores developed.

Occurrence:—This is one of the most abundant, characteristic and widely distributed forms of the Richmond group. It is easily recognized by the quadrate character of its zoœcia, which feature is usually visible in the cross-section furnished by the broken-off ends of the branches.

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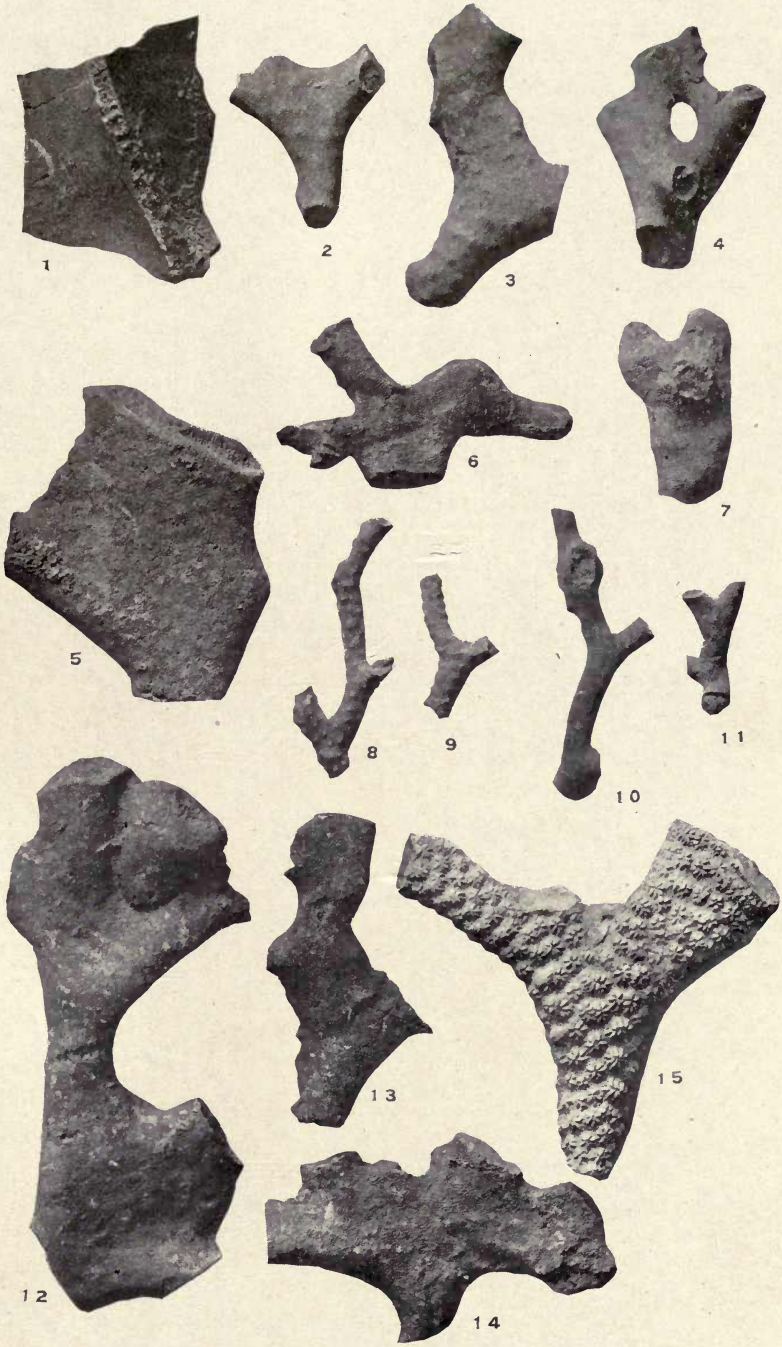


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